4

Psychobiological **A**spects

THE STUDY of Mechanisms that underlie a given behaviour makes an essential supplement to approaches that elucidate its social role. The study reported in chapter 3 indicated that the motivation to use a whispered voice may be a matter of a positive or a negative reinforcement, depending on former experience within a given social context. In the private domain, and particularly at the summit of courtship, partners often develop a high motivation to respond to each other by whispering. In the public domain, on the other hand, personal experience with whispering (e.g. as a co-listener) could contribute to a reduction of its use. Many individuals who had been exposed to whispered words that were not addressed to them, did nevertheless announce a strong interest in co-listening combined with a high curiosity to decode the whispered messages. Results like this suggested putting forward the vigilance-hypothesis (see page 32). This hypothesis predicted that whispering can affect the psychobiological state of recipients, and in particular raise their auditory vigilance.

Vigilance can be defined as a state of being wide-aware and open for several different perceptions (Grillon et al. 1997). Some authors treat this state also as a kind of 'sustained attention' (Hawk et al. 1992).

Most knowledge about vigilance comes from studies of *visual* vigilance (Keverne et al. 1978; Hunter & Skinner 1998), whereas auditory vigilance remained a relative neglected issue. Basically practical reasons contributed to this situation. In the case of visual vigilance, investigators often have access to conspicuous behavioural cues which are related to its performance. Head and eye movements, for example, are commonly accepted as indicators of visual vigilance, and their rates or durations can be taken even as measures of its intensity (for citations see: Todt & Brumm 2001). The few studies which, nevertheless, successfully investigated properties of auditory vigilance, achieved this by specific methodological maneuvers, for instance, by using the so-called 'startle response' as a measure (for citations see Hoffmann-Kuhnt 2003).

In the following, I describe two other studies on the effects of auditory vigilance. Both were designed to test predictions of the vigilance-hypothesis (see above), but they differed in their particular objectives and also their methods. Therefore, they will be introduced and treated separately.

4.1 Levels of Auditory Vigilance

There is evidence that a dark environment can raise the level of auditory vigilance. For instance, blind people who often are constantly monitoring their environment auditorily, are believed to be hypervigilant in this respect. Nevertheless, it remained unclear whether and how such raised vigilance levels can have a positive effect, indeed, on particular perceptional accomplishments. When being exposed to specific acoustical stimuli, blind subjects did not show an increase in startle responsivity compared to sighted individuals. Studies with sighted subjects tested in the dark yielded similar findings (Bachar et al. 1993). Further studies suggested that neither darkness nor the tested deprivation of visual information enhanced the processing of auditory information (Grillon et al. 1997). An earlier study had indicated, however, that this outcome could be different if such deprivation was based on an individual's self-control (Hawk et al. 1992).

In my thesis, I investigated this issue with a modified focus (Figure 4.1). I expected that experimental effects would be stronger if the exposure to whispering would be linked with an exposure to darkness. In order to 'challenge' the subjects I used soft stimuli, which were presented with an amplitude of about 25 dB. During the experiments described in chapter 2.1, this amplitude was found to induce clear differences in a successful decoding of verbal stimuli.

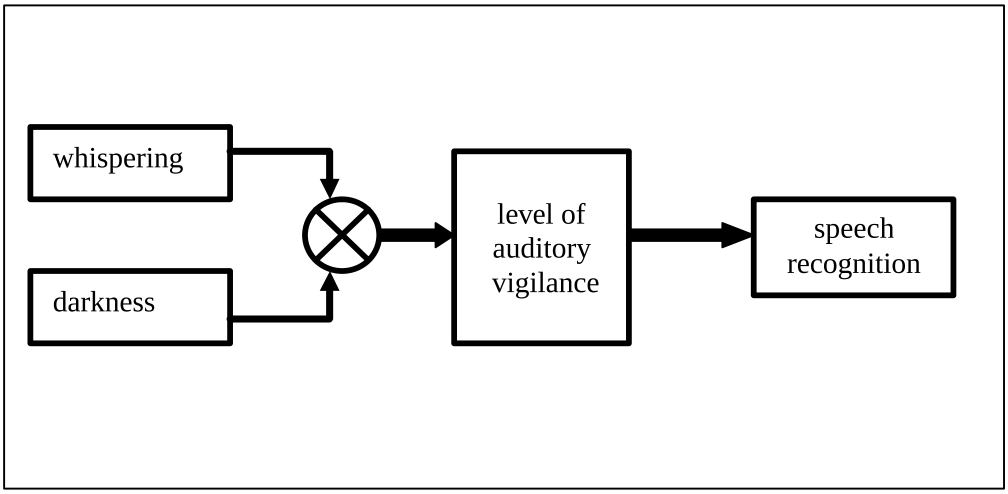

Figure 4.1 : Schema illustrating the concept of the experiment. It describes the prediction that the variables listed on the left side (here: whispering & darkness) raise the level of auditory vigilance, and that this effect would influence the variable on the right side (here: speech recognition).

Methods

Subjects (n=84) were asked to decode auditory stimuli which - via headphones - reached their ear with an amplitude of about 25 dB. Subjects remained uninformed about the scientific aim and other details of the data sampling. Special care was taken to make sure that each subject treated her/his experimental task individually. Stimuli were experimental sets of ten different numbers which beforehand had been recorded with a Sony TC D5 recorder on tape in either a phonated or a whispered expression. Tapes were composed only by numbers that contained four syllables and were presented in a random succession.

Experiments took place in a sound protected test room, where tests were conducted under normal room light or in full dark. The succession of these conditions varied randomly across test sessions. Each test started after a short period of adaptation to either light or darkness (5 min.), then lasted for about 1 min., and finally, was separated from another test by 3 minutes. Immediately after each stimulus subjects had to write down their decoding results on a special list.

For analyses of correct recognitions, the notified numbers were compared to the numbers in the test lists. Errors or hits, respectively, were evaluated according to the different test variables, i.e. voice quality and quality of room enlightment. To test for statistical significance of results, we applied ANOVA or χ^2-methods (df1). Significance was accepted at a level of $p < .05$.

Results

Analyses of correctly decoded verbal stimuli revealed two major results. The success of decoding whispered numbers was clearly below the success of decoding phonated numbers [$F= (1, 83) = 123.37$; $p< .0001$.]. And this was true for either light condition (see Fig. 4.2.).

The other result was found by comparing the decoding success achieved in the dark to the decoding success reached under normal light conditions (Fig. 4.3). The analysis showed that the first one (dark) was slightly better than the latter one (light). Statistically, however, this difference was not significant [$F (1, 83) = 1.99$; $p = .16$]. This finding was similarly expressed for both: phonated numbers and whispered numbers.

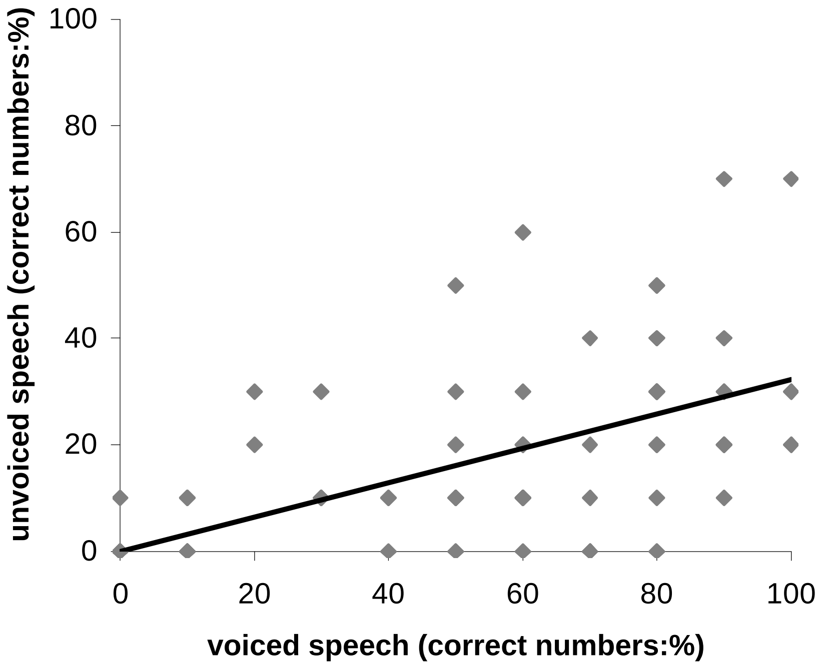

Figure 4.2 : Comparison of numbers presented in a voiced and an unvoiced version and correctly decoded by our subjects (see text).

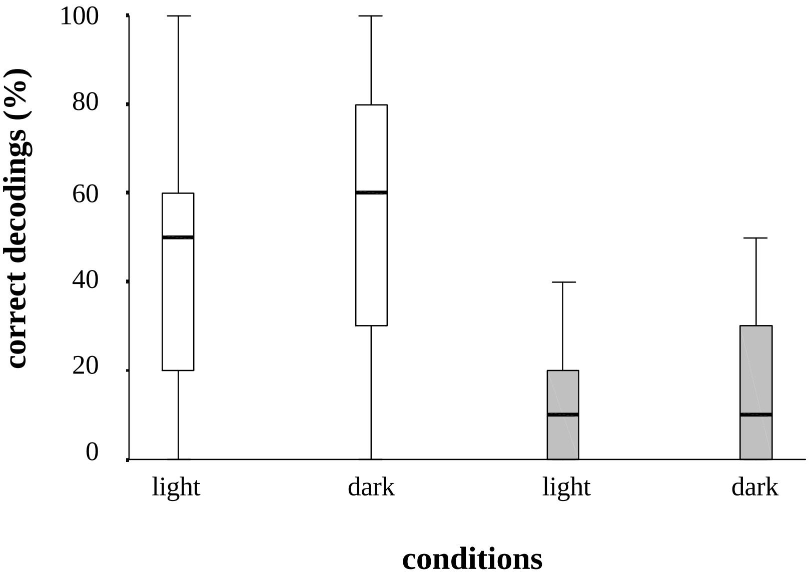

Figure 4.3 : Percentage of correctly decoded stimuli (here: numbers) shown for the two experimental conditions: tests in normal light or in the dark. Left boxplots: phonated numbers. Right boxplots: whispered numbers. Stimuli were presented with an amplitude of about 25 dB.

Conclusions

The results did not confirm my expectation that darkness and/or whispering would improve speech recognition.. Currently, I can not exclude that this result could have been a consequence of the methodological procedure. For example: in the described experiment, subjects had five minutes only to adapt to a given light condition, and such time span could have been just too short for an establishment of distinct darkness-related effects. I assume that a clearly longer exposure to darkness could have raised the auditory vigilance of subjects up to a level which could have improved their decoding success.

On the other hand, however, my results were in line with the findings of Grillon et al. (1997) who reported that darkness did not enhance the processing of auditory information.

With regard to further experiments on the vigilance hypothesis, I had two options: One was to repeat the study with an improved method that could e.g. include procedures of an individual's self-control (Hawk et al. 1992). The other was to develop and use a different approach that would e.g. investigate interactions between effects of both auditory and visual vigilance. For good reasons, my choice was the latter one.

4.2 Auditory Vigilance versus Visual Attention

The study of interference between auditory and visual attentions is an actual topic of psychological research. This topic is usually addressed by dual-tasks experiments (review in Spence & Read 2003). These showed, for instance, that a success in visual spatial discrimination decreased when participants were simultaneously required to monitor an additional modality (audition) for occasional targets, suggesting that similar attentional resources are used to process auditory and visual information (Spence & Driver 1997).

My own study on a possible interaction between auditory vigilance and visual vigilance had been stimulated by a pilot experiment which concentrated on its relationships to a perception of whispering and merits to be briefly sketched here. The experiment took place in a waiting room with a written announcement that this room was video-controlled. Three individuals were involved in this experiment. First, an experimental subject who was asked to read a book chapter in order to later report about its content. Second two individuals who were my helpers and had been instructed to enter into a low-volume conversation with each other, but not with the subject. They were also asked to begin the conversation about five minutes after they had entered the room; either by whispering or by speaking normally. The reading behaviour and especially the eye-movements of the experimental subject were recorded audio-visually. The subject remained uninformed about this and all other experimental details, inclusively the role of my helpers. Analyses of the subject's nystagmus exhibited a clear correlation between the number of nystagmus interruptions and the occurrence of a whispered conversation. The same results were ascertained by similar tests with two other subjects who additionally showed lateral head movements, e.g. short visual checks towards the talking persons. For logistic reasons no further repetitions of the experiment could be done. Hence, it served as a pilot study until now.

Based on the outcome of this experiment, I conducted a further study to the psychobiological aspects of whispering. Here, I wanted to clarify how subjects would deal with a task that required both, auditory vigilance and visual attention. In addition, this study was designed to also test the vigilance-hypothesis.

Methods

Subjects (n= 26) participating in this experiment were tested individual-wise in a sound protected room that is illustrated in Figure 4.4. Their task was to watch a Telefunken A

230 M screen showing a video film taped with a Panasonic HiFi F55 video recorder about well known animals in the Zoological Garden of Leipzig, and also to memorize as much as possible of what they had seen. Subjects were informed about three matters: (a) that their face would be recorded by a video-camera (Sony Handycam CCD-TR 780 E Hi8), (b) that parallel to the film they would hear a sound encoded in an artificial language, and (c) that they would be asked later to retell two times what they had seen in the film. The first time after half of the film, and a second time immediately after the film had ended. In this ‘pause’, the modus of background sound was changed from normal to whispered version, or vice versa, respectively. The film had a length of 2 minutes.

The experimental sound which substituted the original film sound was presented with an amplitude of about 45 dB via AIWA SC-A5 loudspeakers, either from the right or the left side. Whereas the main body of this sound was composed of a language that the subjects could not decode, there were a few verbal cue-stimuli spoken in German language as well, which we had inserted into the sound in a distributed manner. Such cue-stimuli were (a) the name of a given test subject and also the names of four other subjects that were familiar to her/him, plus (b) five nouns and (c) five verbs taken from a catalogue of the most frequent German words. Each complete set of auditory stimuli was given in a phonated and also a whispered version. The succession of version was determined by chance. Subjects were instructed that they would hear the experimental sound in either of such versions, but they remained totally uninformed about the cue-stimuli. Thus, we expected that the cue-stimuli would cause a surprise in our subjects, and thereby provide an additional vigilance-related effect.

Immediately after each test, subjects were asked to note in a multiple choice sheet the zoo animals which they had remembered from the film. These lists served to later search for relationships between experimental variables and possible errors or memory 'black-outs'. Only at the end of the final test, however, subjects were also asked to declare which cue-stimuli they had recognized and remembered. This list of names and words was evaluated, too.

For an additional assessment of experimental effects, the video recordings were evaluated too. Their analyses followed general methods (Todt & Brumm, 2001; Todt 1983), but concentrated especially on stimulus-related behaviours of a subject, and also on (ii) the latency and (iii) the duration of such behaviours. Latency measures referred to the intervals between a stimulus and the onset of e.g. a head movement directed towards a loudspeaker. Duration measures referred to the intervals between such onset and the time when e.g. the head returned to its former (frontal) position. Statistical significance of relationships between variables was tested by a one way ANOVA.

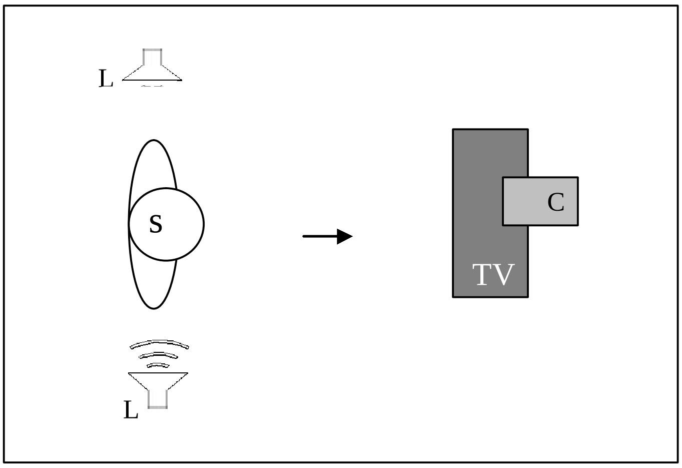

Figure 4.4 : Illustration of experimental setting. S = subject, , C = camcorder, TV = Television screen. L = loudspeaker (for further details of experimental regime see text).

Results

Based on the findings of the pilot study sketched in the introduction I expected that at least some of the subjects would show stimulus related behaviours, such as a short look to one of the loudspeakers. Detailed analyses of the video recordings, however, did not provide evidence for clear-cut stimulus-related changes in the behaviour of subjects, here. In particular, there were no distinct lateral movements that could have served as hints of directed responses. Only in three out of 26 subjects, we found short smiles that followed the occurrence of a cue-stimulus, i.e. their own name or the name of a friend.

In contrast to this inquiry, analyses focused on the names of zoo animals which subjects reported correctly yielded a remarkable result. When the lists of reported names were compared to list of actually depicted species of animals, we found that the proportion of items which subjects post-hoc correctly remembered showed a clear correlation to the mode of auditory stimulation. The number of correct names was smaller when subjects had been presented with whispered stimuli, than with phonated speech (Figure 4.5.). This difference was statistically significant [$F (1, 25) = 19.50$; $p < .001$].

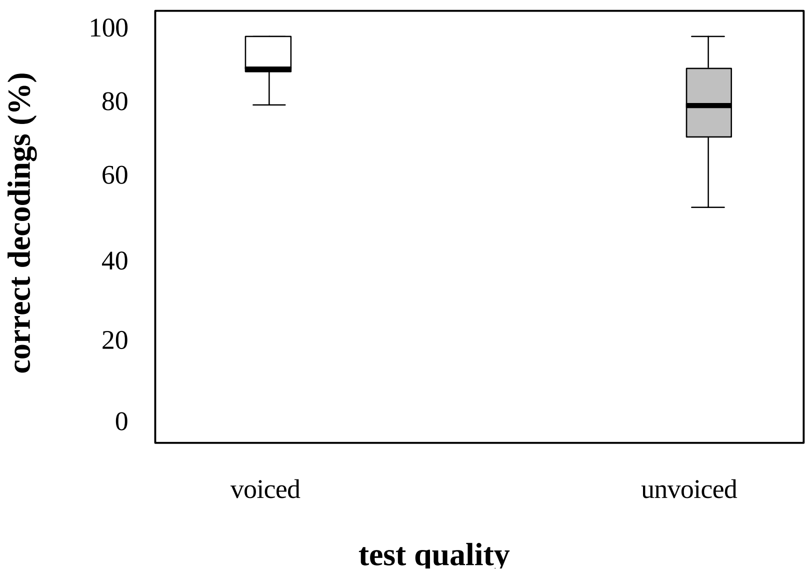

Figure 4. 5 : Percentage of correctly notated names of animals which subjects could see and than had to recognize and memorize. Parallel to these visually stimuli, subjects were exposed to auditory stimulation by either a phonated voice (left) or a whispered voice (right).

Evaluation of the auditory cue-stimuli (names, nouns, verbs), however, which subjects had listed post-hoc, too, did not document test-related differences. In other words, there was no evidence that the subjects recognized and remembered either more or less cue-stimuli, if they experienced them in a whispered version. Nevertheless, there was an interesting side-effect which we discovered when our data were controlled for differences among the correctly listed cue-stimuli. This manoeuvre showed that subjects had recognized and remembered the names of persons in 96% of all cases, whereas they recalled only 20% of the nouns and just 4% of the verbs in a correct manner. This effect was true for both whispered and phonated cue-stimuli. However, as it was not related to the core issues of this study, the effect was not investigated in further detail.

Conclusions

The results described above are in line with the 'vigilance'-hypothesis which predicted that whispering can affect the psychobiological state of recipients, and in particular raise their auditory vigilance. This can be concluded from the finding that only whispered speech, but not phonated speech, had an effect on the dual-task paradigm.

Another effect, however, invites a short additional discussion. It concerns e.g. the singularity of stimulus-related behaviours, e.g. facial expressions and lateral movements, observed during the experiment. I assume that this effect could have been a consequence of the use of loudspeakers. Based on the findings of my pilot study, I conclude that an exposure to auditory stimuli presented by real people could well have induced such lateral checking behaviours.

On the other hand, however, the setting of my dual-task experiment was well designed to test for a possible stimulus-related interference of the two modalities: visual and auditory stimulus quality. The finding, that an exposure to whispered stimuli was significantly linked to a reduced rate of correctly memorized visual stimuli, does nevertheless require a brief consideration, here. I tend to explain the result as a consequence of a raised auditory vigilance which could be induced by whispered stimuli and, at the same time, could have distracted the attention of subjects away from the visual stimuli. But this interpretation does not exclude other ones, currently. In particular, it would be very interesting to know whether the cue-stimuli could have played a role here, too. In addition, it should be clarified which part of the chain of processes mediating between stimulus recognition and memory retrieval was specifically affected by the experiment.

In the chapter 'General Discussion' these results will be compared to the findings of other investigators in more detail.

4.3 Summary

The aim of this part of my thesis was to treat some psychobiological aspects of whispering and especially, to clarify whether this verbal display could raise the auditory vigilance of co-listeners, as predicted by a hypothesis deduced earlier ('vigilance'-hypothesis; see page 32). The study comprised two approaches. The first one explored relationships between whispering, darkness and speech recognition with auditory vigilance as an intervening variable. The second approach was designed to test for a possible interference between auditory vigilance and visual attention. Data analyses yielded the following results.

The experiment on speech recognition did not allow a final statement, yet. Although I found that the decoding success achieved in the dark was better than the decoding success reached under normal light conditions, the effect was invalid for my purpose. First, because it did not differ for whispered and phonated speech; second because it was not statistically significant. This result is in line with findings of Grillon et al. (1997) who reported that darkness did not enhance the processing of auditory information.

The other experiment, provided a better support for the 'vigilance'-hypothesis. In addition, it contributed to the dual-task paradigm and the discussion of conflicts between auditory vigilance and visual attention. In this experiment, subjects had to watch a video film and were asked to memorize as much of its biological details as possible. They were instructed that the normal film sound was substituted by an artificial sound track (here: a passage spoken in an artificial language and by either a phonated or a whispered voice).

Subjects were not instructed, however, that this sound served to distract their attention from observing the film. Analyses of correct notations that the subjects had delivered immediately after each test, documented that an exposure to whispering had been more effective in distracting the visual attention of subjects than an exposure to voiced form of spoken language. This difference was statistically significant [ANOVA; $F (1, 25) = 19.50$; $p < .001$].